RANCH DAY

OCTOBER 13, 1952

New Mexico Experiment Station, New Mexico Extension Service
Southwestern Forest and Range Experiment Station

Good Management

is

Drought Insurance

Experimental Ranch

New Mexico College of A. and M. A.

Jornada Experimental Range

Southwestern Forest and Range Experimental Station

P R O G R A M

TWELFTH ANNUAL RANCH DAY
Jornada Experimental Range and College Ranch
October 13, 1952
Las Cruces, New Mexico
Ivan Watson, New Mexico Extension Service, Presiding

8:00 a.m. Leave Dona Ana Courthouse, Las Cruces, New Mexico.

8:35 a.m. Stuart Well Rain Gage, Jornada Experimental Range. The Jornada Experimental Range -- C. Kenneth Pearse, Chief, Division of Range Research, Southwestern Forest & Range Experiment Station.

Climatic variations in southern New Mexico -- Fred N. Ares, Superintendent, Jornada Experimental Range.

9:30 a.m. Black Grama Quadrat "U". Climate and range vegetation -- Harold A. Paulsen, Jr., Range Conservationist, Jornada Experimental Range.

Adjusting range management to the climate -- Fred N. Ares.

10:35 a.m. Mesquite Invasion Transect. Climate in relation to shrub invasion and control -- George E. Glendening, Range Conservationist, Southwestern Forest & Range Experiment Station.

11:30 a.m. Headquarters, Jornada Experimental Range.
Viewing of Jornada cattle -- B. A. Christmas, Cooperator.

Chuck Wagon Lunch

Welcome - Raymond Price, Director, Southwestern Forest & Range Experiment Station, and John W. Branson, President, New Mexico College of Agriculture and Mechanic Arts.

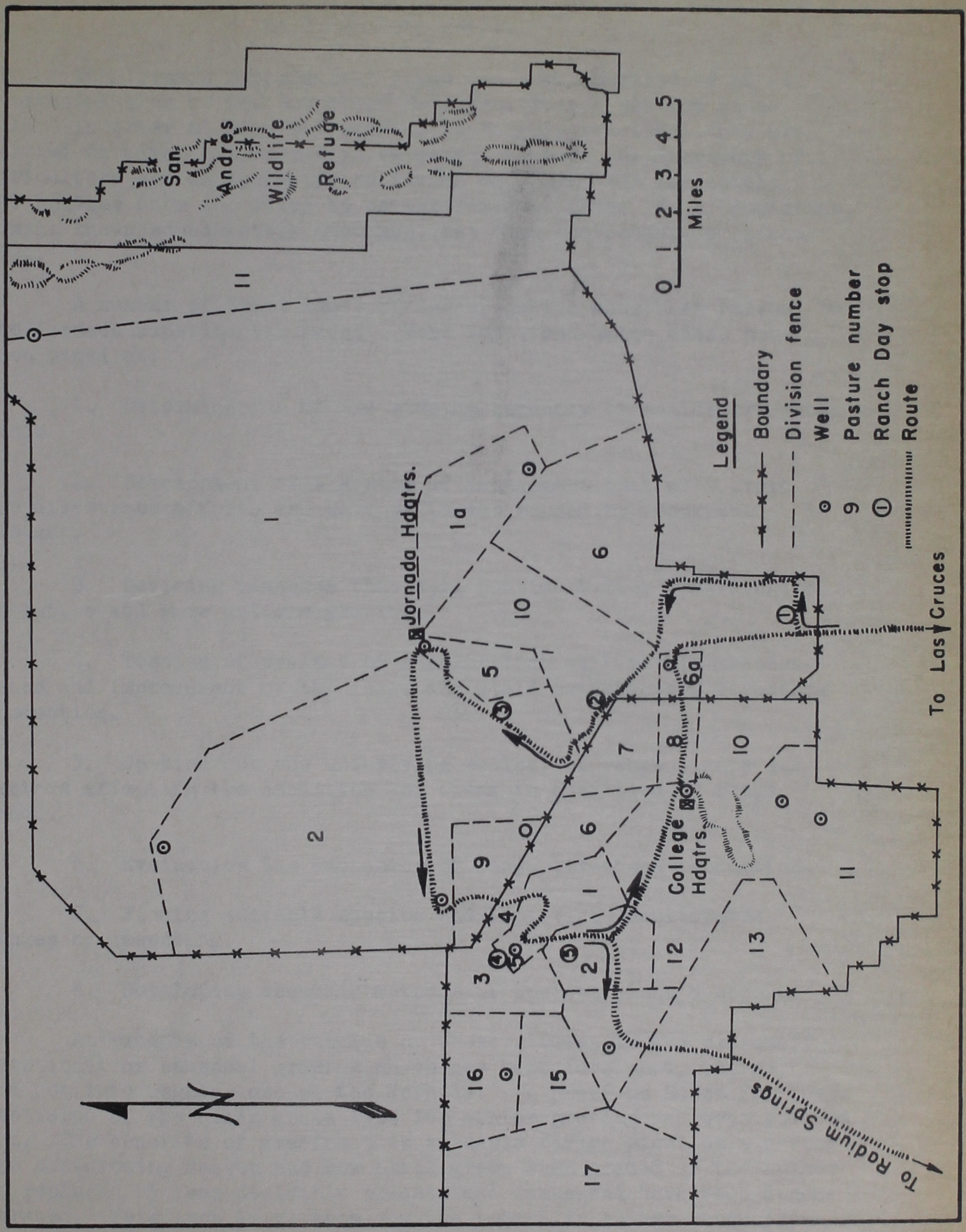
Introduction of Guests.

Climatic fluctuations and the economy of the Southwest -- Dr. E. J. Workman, President, New Mexico Institute of Mining and Technology, Socorro, New Mexico.

2:00 p.m. Demonstration of wood fence post preservation treatment.
--Lincoln A. Mueller, Chief, Forest Utilization Service, Southwestern Forest and Range Experiment Station.

3:10 p.m. Camp Well, College Ranch. The effect of rainfall on the production of range cattle. Professor J. H. Knox, Department of Animal Husbandry, New Mexico College of Agriculture and Mechanic Arts.

3:45 p.m. Pasture 2, College Ranch. Management and production on the College Ranch during drought. K. A. Valentine, Assoc. Prof., and J. J. Norris, Asst. Prof., Department of Animal Husbandry, New Mexico College of Agriculture and Mechanic Arts.



PORTION OF COLLEGE RANCH AND JORNADA EXPERIMENTAL RANGE
SHOWING RANCH DAY ROUTE

THE JORNADA EXPERIMENTAL RANGE

By C. Kenneth Pearse

The Jornada Experimental Range has been operated as an experimental area by the Branch of Research, Forest Service since 1915. In order to make the studies thoroughly practical they are carried on under a cooperative agreement between the Secretary of Agriculture and an operating cattleman who furnishes the cattle and handles them according to an experimental plan. B. A. Christmas, a well known southwestern stockman, has been the cooperator since 1934.

A number of broad lines of investigation have been pursued on the Jornada Experimental Range. Most important among these have been aimed at:

1. Determination of the grazing capacity of semidesert range lands.

2. Development of a system of management that will avoid the disastrous effects and serious losses caused by recurrent drought.

3. Devising measures that will provide better distribution of cattle and more uniform grazing.

4. Testing of systems of grazing that will permit maintenance and improvement of the range and yield satisfactory livestock production.

5. Working out the underlying ecology of range plants and factors affecting the condition and trend in condition of range lands.

6. Evaluating the economics of range livestock production.

7. Finding suitable species and improving deteriorated ranges by reseeding.

8. Developing economic methods of noxious plant control.

An example of the results of these studies is the system of rotational or seasonal grazing which has been developed, tested, and put into regular use on the Jornada. On previous Ranch Day tours the value of the black grama type for winter grazing has been pointed out. The benefits of grazing this valuable forage plant only during the non-growing season and how black grama when grazed in the summer is replaced by less desirable grasses and snakeweed have been demonstrated. This stop is to show you the tobosa or summer range type.

Tobosa grass produces a great volume of forage as the result of summer flood runoff onto swale areas. During the growing season it is both palatable and nutritious and full use is made of it at that time.

The principal subject of Ranch Day this year is climate and how it is related to grazing and livestock production on southwestern ranges. The factor of climate is especially important in range operations. Drought and the threat of drought is a familiar experience. The Jornada is well suited for a discussion of this kind because the long records of climate and vegetation show recurrent drought and its effect on range plants and forage and livestock production.

As the tour progresses, several points should be kept in mind. Rainfall on the Jornada averages less than 9 inches per year. Evaporation is high, amounting to over 100-inches from a free water surface. Sandy soils are droughty and subject to blowing. On the whole, growing conditions are not favorable for plant growth.

More than 50 percent of the rainfall is received during the three summer months and more than 90 percent of the forage growth is made during that period. Accordingly, what you see on the ground now is the forage supply until the beginning of summer rains next year. Occasionally when winter and spring rains come, some annuals are produced but this type of growth can't be counted on for dependable forage.

You are seeing the Jornada at a most unfavorable period in its history so far as climate is concerned. The last 7 years have been drought years. This summer 3.07 inches of rainfall was received, and while this is better than last year, it is still only 64 percent of average. Everything considered, the response of the vegetation and the size of the forage crop this year is gratifying considering the drought years that have been weathered. There has been some serious loss in density on parts of the range as the result of prolonged drought and severe blowing of the exposed soil. On the whole, however, the valuable forage plants are coming through and responding to management.

Over the drought period animal numbers on the Jornada Experimental Range have been sharply reduced. No forced sales have been necessary, however. The breeding herd, which has been retained, is vigorous and high calf crops have been maintained. Death losses last year were less than 1 percent.

The unprecedented drought of the past 7 years has given some extremely valuable experience and research records. These will help in further developing sound practical systems of grazing management for semidesert ranges. Some of the results will be brought out during the day's tour.

CLIMATIC VARIATIONS IN SOUTHERN NEW MEXICO

By Fred N. Ares

The climate of southern New Mexico is highly variable but on the whole it is not conducive to a luxuriant vegetation. Temperatures are mild and from late March to late October are favorable for plant growth. But for much of this time moisture is deficient and growth is limited to the period of July to October when summer rains occur.

The moisture deficiency is intensified by high evaporation rates, and high winds. Evaporation from a free water surface totals about 100 inches per year--more than 10 times the amount received as precipitation. Wind movement averages about 35,000 miles per year, a rate that, although less than that recorded in some other parts of the country, is enough to make heavy demands on soil moisture and plant life. Both wind movement and evaporation are greatest in the dry spring period making this an extremely critical time in the development and subsistence of the plants.

Rainfall is unpredictable in its amount, timing, and distribution. The region constantly faces the threat of devastating drought; it may come as a single year with practically no effective rainfall, or it may strike as a group of consecutive low-rainfall years. This provides many uncertainties in the range livestock industry. Livestock losses, low calf crops, retarded growth, range depletion, and heavy expense too often are associated with drought and make it essential for the successful stockman to plan for recurrent droughts. Drought years come without warning. If the occurrence, duration, and intensity of droughts could be more accurately forecast, a big step forward would be taken in removing some of the risks connected with cattle production in this locality. This goal may be reached when centuries of rainfall records are available for analysis. For the present, however, experience has shown that in even a comparatively short span of 8 to 10 years there are 3 to 4 years when rainfall is deficient and drought conditions exist. These years are likely to be consecutive and this in effect delivers a "one-two" punch with telling results.

Southwestern Rainfall Records Show Apparent Cycles

From about a decade before the Civil War, rainfall records have been collected in Dona Ana County. These data came from frontier Army posts beginning in 1852 and continuing up to 1892 when the State College climatic station was established. This is a span of 99 years, but data are incomplete or missing for 13 years, leaving only 86 years of records.

Probably the most noteworthy thing about the record is the apparent grouping of the years into 4 cycles with the last 8 years

indicating the beginning of another cycle dating from 1944. For the first 21 years, the rainfall was 8 percent below the 86-year mean; for the second cycle of 20 years, 14 percent above; for the third of 19 years, 14 percent below; and for the fourth of 18 years, 13 percent above. The first 8 years of the present period stand at an average of 20 percent below the 86-year mean, surely not a very encouraging picture. However, it must be remembered that within the dry periods there are years of above average and even a few of exceptional rainfall; just as in wet periods there are some very dry years, as witness 1934. The data show that any tendency toward a cyclic pattern is not well enough established to serve as a basis for prediction. Even though last year and the preceding 7 years have been dry, there is no indication of what next year will bring.

Jornada Rainfall Shows Cycles Too

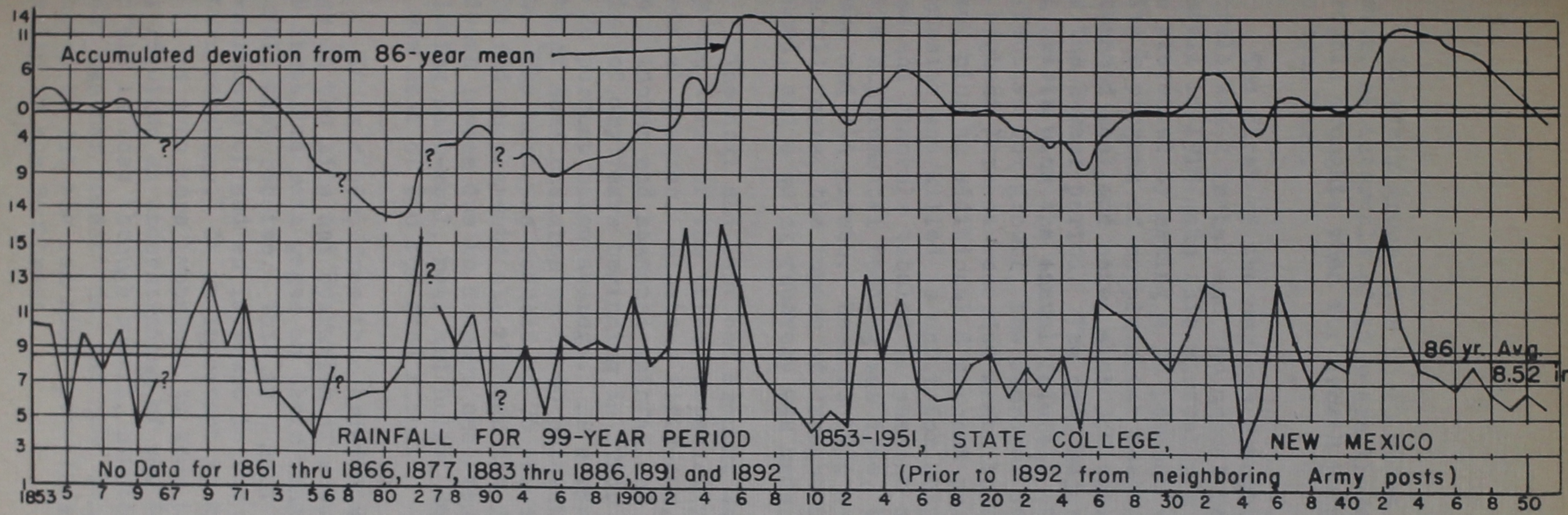
Rainfall records from the Jornada covering a 37-year period, from 1915 to 1951, reveal about the same general pattern as the longer record. The first 11 years of the Jornada's record fall within the latter part of the third dry cycle of the longer record ending in 1924. Then follows a 19-year period with above-average precipitation reaching the climax in 1941-42. Rainfall averaged 15 percent above the mean and included such extremes as 1926 and 1941, both with twice the average annual rainfall; and 1934 with less than half the mean. Beginning in 1945, the trend reverses and starts downward, the remaining 7 years showing a decline of 26 percent below the mean.

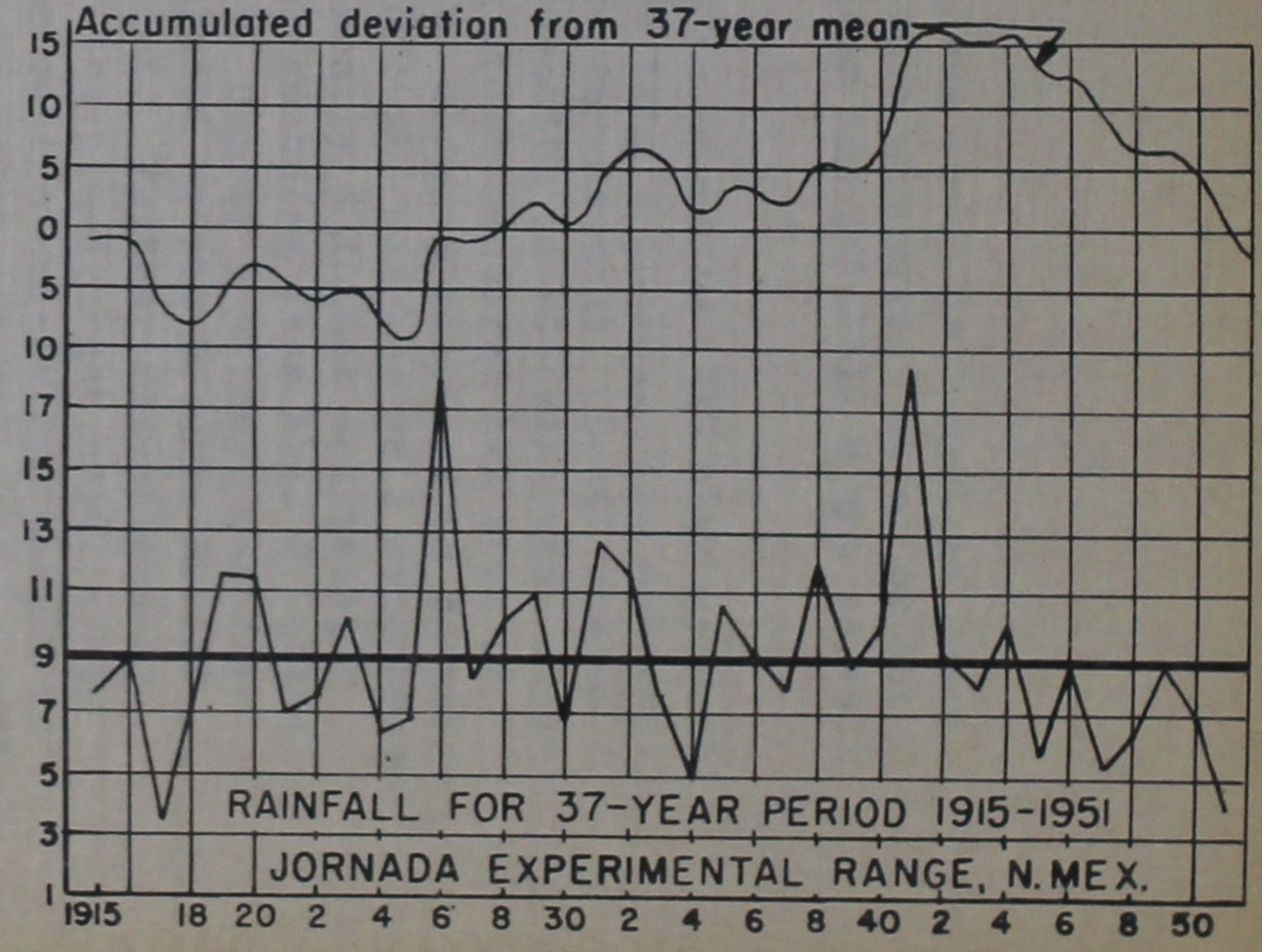
Seasonal Fluctuations

Seasonal rainfall data are also available from the Jornada for the 37-year period. By seasonal is meant the rainfall of the growing season, ordinarily from July to September, inclusive, when normally about 50 percent of the total annual rainfall is received and about 90 percent of the forage is produced. However, average rainfall for this season does not mean that forage growth will be average. Effectiveness of rainfall for growth is determined not only by the amount but also by its timing and distribution. For example, a rain to be effective should be not less than one-half inch in amount. But this or even larger amounts are not effective unless followed by more showers within a reasonable time. A hot, dry spell can soon cancel out the effects of a good rain.

Often showers a mile or more in width move across the range for a few miles leaving dry soil a short distance away from the storm path. Records from a single gage cannot be considered typical for a very large area. Rainfall varies not only from season to season, and from

ANNUAL RAINFALL
&
ACCUMULATED DEVIATIONS
FROM LONG TIME MEANS
IN
SOUTHERN NEW MEXICO


Accumulated deviation from 86-year mean
RAINFALL FOR 99-YEAR PERIOD 1853-1951, STATE COLLEGE, NEW MEXICO
No Data for 1861 thru 1866, 1877, 1883 thru 1886, 1891 and 1892
(Prior to 1892 from neighboring Army posts)
86 yr. Avg.
8.52 ins.



In every group of 8 to 10 years there are 3 or 4 drought years. However, at intervals of 17 years there have occurred 3 major or catastrophic droughts when for growth purposes the rainfall might as well have been zero.

The first of the serious droughts occurred in 1917 when seasonal rainfall was 2 inches and the annual less than 4 inches. Low seasonal rainfall in 1918 made this virtually a 2-year drought. Death losses were prevented by making a 30 percent reduction in stocking and undertaking a program of supplemental feeding which required 121 tons of cottonseed meal and cake, with 350 tons of chopped roapweed as roughage over the 2-year period. The next major drought was the well remembered 1934 crisis when the annual rainfall of nearly 5 inches was totally ineffective for growth, the seasonal average being less than 2 inches. The highest Jornada recorded death loss of nearly 5 percent was suffered, plus an additional 8 percent purchased by the Drought Relief Commission and killed as unfit for shipment. Further reductions by sales and removals totaled 71 percent of the pre-drought herd. Very little supplemental feeding was done, the cattle subsisting mainly on browse and old growth. Because 1934 was preceded and followed by good rainfall years, the impact of drought on the vegetation was greatly reduced, and a quick recovery was made.

The next and last bad drought was that of 1951. This was probably the worst of the three, especially in its damaging effects on the perennial grasses. Nineteen fifty-one, with an annual rainfall of less than 4 inches and seasonal rainfall of less than 2 inches, climaxed a series of dry years beginning in 1945. The mean for this 7-year period was 26 percent below average. As a result, it is estimated that in some parts of some pastures up to 90 percent of the perennial grass stand was lost. The herd was reduced by 76 percent, and the remaining cattle had to be fed supplements all through the fall, winter, and spring months. No death losses due to drought occurred, but a total of 231 tons of feed, including salt-meal, meal and hulls, and range pellets, was fed at a per cow cost of $50 for feed alone.

It is clear, from this brief discussion, that climate looms large in the life and operation of southwestern cattlemen. Many ranchers have installed rain gages on their ranges and keep good records of the rainfall they receive. This is a good sign of the times; it indicates an awareness of and an interest in the natural forces that affect southwestern ranching. It is important to know the amount of rain that falls. But it is even more important to know how to utilize it most effectively. This requires an understanding of the factors that determine how much rainfall is lost through runoff, how the forage plants respond to different weather conditions, and how range and herd management can be adjusted to fit the ranching operations into the kind of climate that prevails in the Southwest.

month to month, but also by localities. For example, average seasonal precipitation from Stuart Well gaging station was 25 percent greater over a 14-year period than for the Red Lake gage located on the Jornada mesa 15 miles north. To offset this and obtain reliable annual and seasonal averages, 23 rain gages are distributed over the Jornada range.

The effectiveness of precipitation depends on the condition of the soil as well as on the character of the rainfall. Hard packed soil containing practically no litter or duff absorbs moisture slowly, thus reducing the value of rainfall. On such soils, many storms, especially the violent rainstorms, are partly ineffective in that most of the water is lost to the plants by destructive surface runoff. Even though man may not greatly modify the amount of rain that falls, he can greatly increase the amount that is available to plants by keeping the vegetational cover healthy, by keeping the soil protected and blanketed with litter, and by otherwise managing the land to keep runoff at a minimum.

Rainfall variations must be considered in the experiments being conducted at the Jornada Experimental Range. For example, records have been kept to determine the comparative weight gains of cattle grazing on tobosa and on black grama ranges in the summer season. Only two of the six years of the study had comparable amounts as well as timing and distribution of seasonal rainfall in the two pastures involved. The data for the other four years is of little direct value. This illustrates the long periods of time required to evaluate the factors which influence range use.

Impact of Drought on the Jornada Range

Conservative stocking is a proven means of meeting the threat of drought. Some droughts, however, have been so severe as to require heavy supplemental feeding and drastic adjustments in stocking. Inasmuch as one of the principal objectives has been to develop a plan of management to eliminate the disastrous effects or soften the impact of drought, these occasions have in a way been blessings in disguise in that the operation has been tested, weak spots revealed, and needs for further adjustment indicated. For example, it was learned early that the best protection against heavy death losses was a flexible plan of herd management, the principal feature of which was the low ratio of breeding cows to total stocking. This made possible a quick reduction during drought to half the average grazing capacity; accomplished by heavy culling and selling off all calves and yearlings and other easily salable livestock.

CLIMATE AND RANGE VEGETATION

By H. A. Paulsen, Jr.

The close relationship between climate and range vegetation is the result of centuries of plant differentiation and adaptation. Through elimination of non-adapted species and development of new forms, many different types of plants have evolved under the wide variety of climatic conditions which are present throughout the world. Thus some plants are capable of withstanding prolonged droughts while others can survive only in the presence of standing water. Between these two extremes there are all gradations; for example, junipers which can survive drier climatic conditions than most conifers and short grasses whose growth habit makes them more drought resistant than the taller prairie grasses. Because of such adaptations each major climatic region has developed a dominant vegetation composed of several plants which are best suited to the existing climate.

Moisture, Temperature, and Light

Of the climatic factors which are considered most important to plants, moisture, temperature, and light are considered as the big three. While these always work together, climatic relationships are easier to understand if each factor is considered individually.

Little needs to be said of the importance of moisture to plants. The effects of a shortage of precipitation on the grass forage are readily discernible. Equally important with the amount of moisture is its timing and distribution. Rainfall during the winter months is of little direct value to the summer growing grasses. In the summer when temperatures are favorable for grass growth, the summer showers must be spaced to provide moisture over the period required to complete the annual growth cycle.

There are many things which have a bearing upon the effectiveness of the rains. One of these deserves special mention; that is the condition of the moisture storage reservoir, or, in other words, the soil. If it is in good condition the storage capacity is increased many times as well as the rate at which it can take up water, and less is therefore lost by surface runoff.

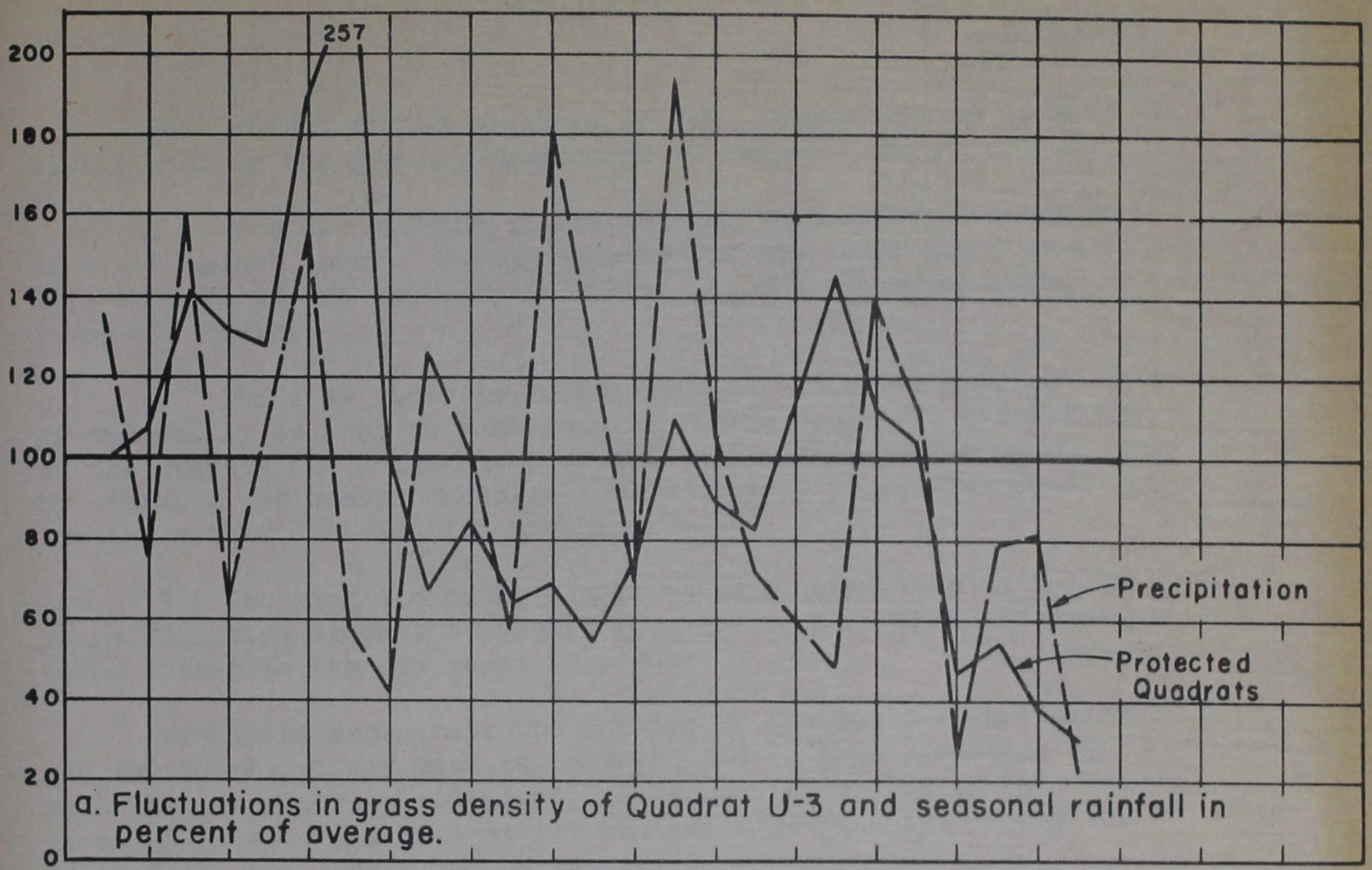
Temperature influences every chemical and physical process in plants. It is required for germination of the seed, sustaining the plant, and the reproductive processes. Largely because of the influence of temperature, flowering of the same species of plant is retarded four days for each degree of latitude north or south of the equator and also for each 400-foot increase in altitude. The favorable temperature range is usually narrow for specific plants but some will thrive in hot springs at 200° F. and others can survive 90° below zero Fahrenheit.

Since the first charting, grazing use in this area has been light. Less than 75 percent of the height growth and 40 percent of the volume or weight of black grama herbage has been grazed.

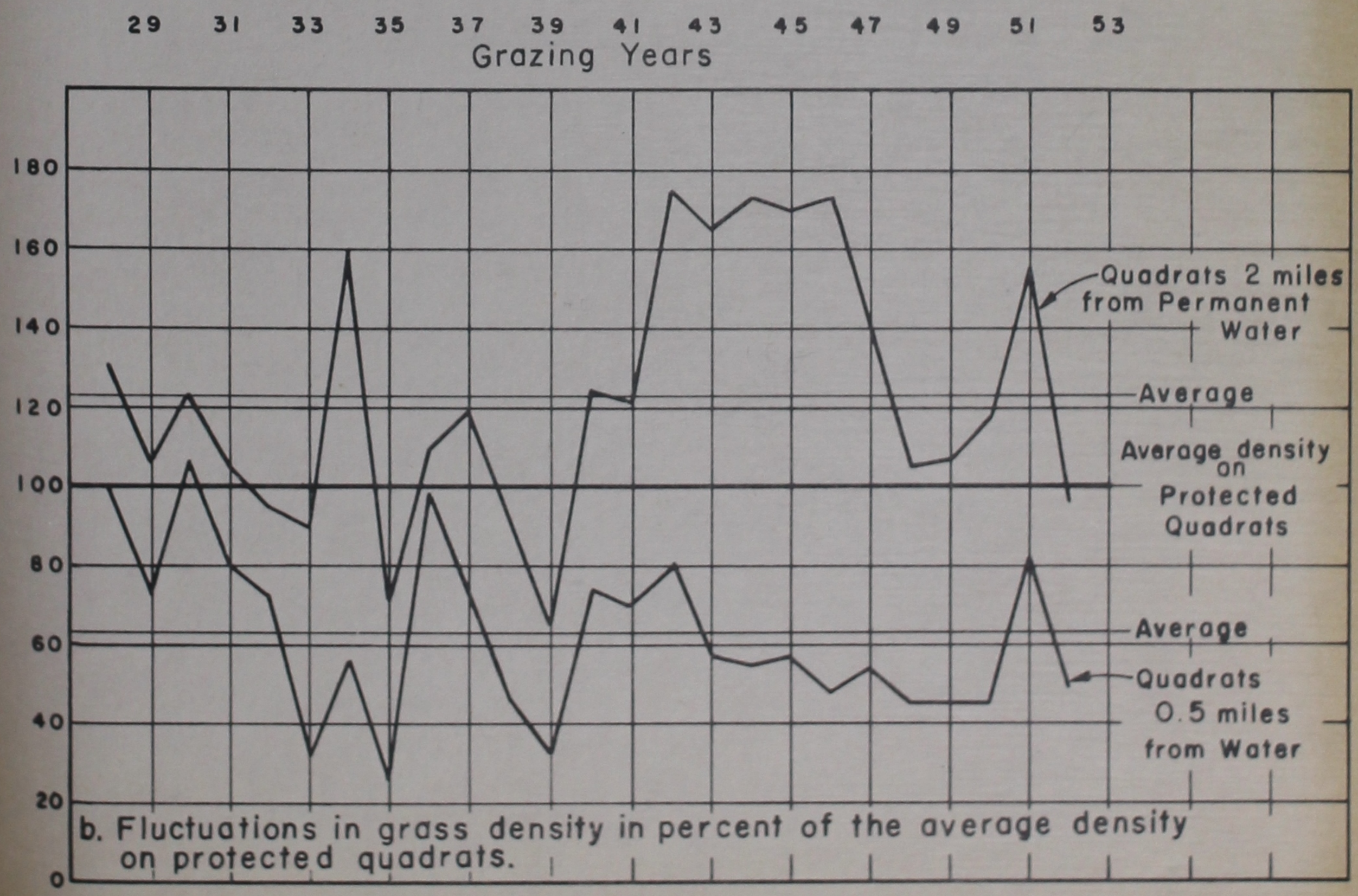
The original grass density when the quadrat in this area was installed was 960 square centimeters. Over the 25 years of charting the plant density has averaged 958 square centimeters but has varied from as much as 2,472 to as little as 287 square centimeters. That the starting density and the 25-year average are the same is only coincidental.

Closer study of the quadrat records yield some interesting information. Following its establishment in 1928 there was a period of 8 years when the quadrat averaged 45 percent above the long-time average. Precipitation averaged 99 percent of normal for this period but was characterized by 4 of the 8 years averaging only 60 percent of the normal. Two of the low rainfall years occurred simultaneously and were followed by a reduction of the grass stand for 8 of the next 9 years. During this next period, however, rainfall averaged 115 percent of normal. Following the extreme drought of 1934 to 1935 the grasses on this quadrat did not start to come back until the early 1940's. Recovery was not complete, however, before the dry years of the middle and late forties set in. The vegetation density declined rapidly in the dry years indicating a low vigor of the plants when the extreme droughts of 1948 and 1951 occurred. In 1951 the grasses and precipitation reached their lowest point of the entire period of record. From previous studies a still further reduction of the black grama may be expected this year because of the very deficient rainfall last year.

A comparison of several quadrats two miles from water with those only one-half mile from water highlights some of the effects of grazing on the grass vegetation. The records of four protected quadrats have been used as a basis for comparison of the other two groups. By plotting grass density of the protected quadrats as 100 percent for the period and the average density of the other quadrats in percent of the density of protected quadrats a rough measure of the effects of grazing intensity upon the vegetation has been obtained. The density of the quadrats two miles from water was nearly 30 percent higher than the protected quadrats at the first charting. During the first half of the period the two groups of grazed quadrats would have been very similar if the density had originally been the same. However, after the drought of the mid-thirties, the grass density on the quadrats one-half mile from water did not respond as rapidly nor as much to the favorable years which followed. The chart also indicates that the density on the quadrats two miles from water declined very slowly during the period of low rainfall years beginning in 1944.



a. Fluctuations in grass density of Quadrat U-3 and seasonal rainfall in percent of average.



b. Fluctuations in grass density in percent of the average density on protected quadrats.

Some points of the analysis of the Jornada quadrat records significant in the grazing management of semiarid rangelands are:

1. Moderate grazing is not detrimental to the maintenance of a good grass cover. During extreme drought years the grasses will be reduced but recovery is rapid with the return of more favorable years.

2. The area close to permanent water which is heavily grazed should be kept to a minimum to prevent complete destruction of the grasses and enlargement of the area. This can be accomplished by avoiding too heavy concentrations of cattle around permanent water through proper distribution measures.

3. Stocking increases should be made cautiously in favorable years following drought to insure recovery of the stand and prevent undue losses in the dry years to come.

With good management the grasses of the semidesert type are adapted to resist dry heat and drought and to take advantage of rain when it comes. Good growth in season, retention of feed values in cured forage, and mild winter weather make this type among the best of the yearlong breeding ranges.

High temperatures mean increased physiological activity in plants. It has been shown that, while there is a wide difference in heat resistance of various grasses, an accumulation of food reserves is essential in all species to prevent heat injury and death. Moderate grazing is necessary if sufficient food reserves are to be built up to enable drought hardening of the plants when rainfall is deficient.

Light from the sun, the third main climatic factor, is essential for growth of range plants through its function in the process of food manufacture and other physiological plant processes. Light is not an important limiting factor in southwestern grasslands.

Other factors which are of special significance in the Southwest are the high evaporation rate, the low relative humidity, and the frequent strong, desiccating winds. All three tend to lower the plant and soil moisture thereby increasing the severity of the conditions necessary for plant survival.

While climate is usually expressed in terms of averages, means, and other general terms, the details of climate in the immediate locality of individual grass plants are more significant. This is known as the microclimate. Its importance can be shown by two potted grasses, one clipped to simulate close grazing and the other with no leafage removed. In the latter, it is not hard to see how this plant would modify the effects of the microclimate. The soil and stems under the umbrella of vegetation are protected from the direct effects of the sun and wind, evaporation is lowered, the impact of rainfall is minimized, and surface runoff is diverted and retarded, permitting more water to soak into a more receptive soil. During the summer growing season winds do not carry the dust that they do in the spring even though the surface soil may be equally dry at both times. This is due to the breaking action of the vegetation upon the wind which prevents the soil particles from being picked up and moved. It illustrates how alteration of the microclimate can modify the larger features of the climate.

Range Vegetation a Product of Environment

Whether or not it is consciously recognized, the range vegetation develops in balance with the many factors which constitute its environment. If one or a combination of the factors is altered sufficiently, a change in the vegetation occurs. Fluctuations of this nature occurred in the past due to one causative agent or another. Another factor was added with the introduction of the domestic grazing animal. Some modification of the vegetation is to be expected with this introduction, however, in most instances, this can be kept to a minimum through careful integration of the grazing use, the climate, and the vegetation.

Forage plants make certain definite responses to the environmental conditions to which they are exposed. Just as some grasses and other plants increase in size and numbers during good years, they also decrease during less favorable periods. Snakeweed, annual grasses, and weeds are able to increase when other more desirable plants decrease. Dropseeds are able to take quick advantage of increased rains following dry periods, and may be very conspicuous in the early years of recovery.

The stand and vigor of black grama in any one year are influenced most by the annual precipitation of the preceding twelve months. The most beneficial distribution of precipitation consists of relatively dry winters sandwiched between wet autumns and springs. This pattern is favorable for both density and height growth. An additional inch of precipitation during the preceding year results in an average increase of plant area of about 5-1/2 square inches per square meter. Height growth increases about 1-1/2 inches with each additional inch of current summer precipitation.

The nutritional value of the forage is also dependent upon climate. Work at the State College has shown that a primary reason for the comparatively high protein values of black grama during the winter is the low amount of winter moisture which the area receives. During those occasional years when winter precipitation is high much of the protein and phosphorus is leached.

Quadrats Show Plant Behavior

The black grama type in which we are standing is close to the location of a quadrat or small, detailed study plot. By means of mapping or charting the vegetation on quadrats, accurate records of the vegetation and changes in vegetation can be obtained. Through annual charting of them a valuable record of plant history has been obtained; many of the quadrats have been charted annually since 1915. The quadrats are not now always representative of the surrounding area but they were originally located for their typicality of the area.

This quadrat, one of a group designated as the "U" series, was established in 1928. Others in the series are located at half-mile intervals between here and South Well. Since 1928 the pasture in which the "U" quadrats are located has usually been lightly grazed during the summer growing season and more heavily stocked in the winter-spring season. From 1916 to 1925 it was used exclusively for winter-spring grazing. Following two years of non-use the season of grazing was predominantly light summer and full winter-spring use until 1938; then followed five years of yearlong use and then light summer and full winter-spring use to the present.

ADJUST RANGE MANAGEMENT TO THE CLIMATE

By Fred N. Ares

The Forage Crop

While the southwestern stockman may be plagued by heat, drought, and drying winds, he is at least fortunate in having a rainfall pattern that permits a summer growing season. Most of the plants that produce his forage crop complete their growth by the time his animals are ready for market. At round-up time in the fall the stockman can see his supply of forage on the ground for the coming year. This is his "hay stack" and it should serve as the basis for his year's operations. Some winter and spring annuals may be produced in some years and these provide a welcome green supplement to the cured grasses and browse. But winter growth cannot be counted on; it is best to consider it as a safety factor that will be valuable if available. Then, if it fails to materialize, it will not be missed. In developing annual plans of management in the Southwest, the only safe rule is to stock on the basis of forage on the ground each fall.

The two principal forage-producing grasses on the Jornada Experimental Range and similar areas are black grama and tobosa. Studies have shown that tobosa can be maintained in a high state of productivity when grazed during the summer growing season, if 4 inches or more of a stubble is left on the ground. Tobosa plants clipped to a height of 4 inches yielded 11 times as much as plants clipped to 2 inches over a 4-year period. Because tobosa flats and swales are extensive and production as a result of summer rains and runoff is high, there is usually little difficulty in keeping the utilization of tobosa at a safe level. Every effort is made to keep cattle on tobosa range as much as possible during the time when it is green, palatable, and nutritious.

Black grama, which provides the bulk of the winter grazing, should also be grazed so as to leave at least a 4-inch stubble. Closer grazing will result in rapid death of plants and their replacement by less valuable grasses and weeds. Grazing so as to leave an average 4-inch stubble will result in taking about 40 percent of the total herbage production. A range so used will appear to be rather lightly grazed, but from 70 to 80 percent of the height growth will have been taken. About one-fifth of the flower stalks should be left. These standards of use are for ranges in good condition with loose sandy soils such as characterize much of southern New Mexico. On deteriorated ranges that need to be rebuilt more conservative use should be followed.

Rainfall and the Forage Crop

Forage production depends largely on the total amount of rainfall. However, the character of precipitation, its seasonal distribution, and the condition of the soil and vegetation may also profoundly influence forage production. There is a close correlation between the total rainfall and forage production on ranges in good condition. Years of above average rainfall result in increased forage crops largely because of increased height growth. Years with below average rainfall result in less height growth and lowered herbage production. Prolonged drought, continued too heavy grazing, or both, reduce the vigor of the forage plants. When this happens parts or all of the weakened plants die and forage production is further reduced. To minimize the impact of drought on the desirable grasses, grazing should be carefully managed for several years following severe drought. Three to five years are sometimes needed to restore the density of drought depleted stands.

Records on the Jornada provide a good picture of the variation in forage production from year to year. In one year a forage crop that would maintain 3,057 animal units was obtained, while in the lowest year of record only 556 animal units could have been carried. This is a variation of from 37 to 201 percent of the average.

Forage Crops and Herd Management

The forage crop may be likened to hay in a stack, too many cattle at the stack and only a bare maintenance ration is provided. A lesser number will not only maintain themselves in condition but will also produce an increment in weight gains or calves, or both. And, as has been demonstrated, fluctuating forage growth may provide a very small stack one year, a large one the next, but never the same every year.

Attempts to adjust stocking to this highly variable forage crop can have disastrous results. A breeding herd built up to use most of the forage in good or even average years cannot be maintained in dry years. Accordingly, the practical way is to stock conservatively. Stocking at a rate of 65 percent of the average forage crop gives a margin of safety. Adequate forage would have been provided in 33 of the 37 years since forage crop records were begun in 1916. Thus more drastic reductions are needed in only the most severe drought years. When extra forage is available as a result of favorable growing conditions some extra cattle can be brought in, or the forage can be used as a reserve for subsequent lean years.

JORNADA EXPERIMENTAL RANGE

Annual Forage Crops, 1916-1952

Forage crop expressed in number of cattle yearlong

3,200
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0

Average 1426.7

65 % of average 9274

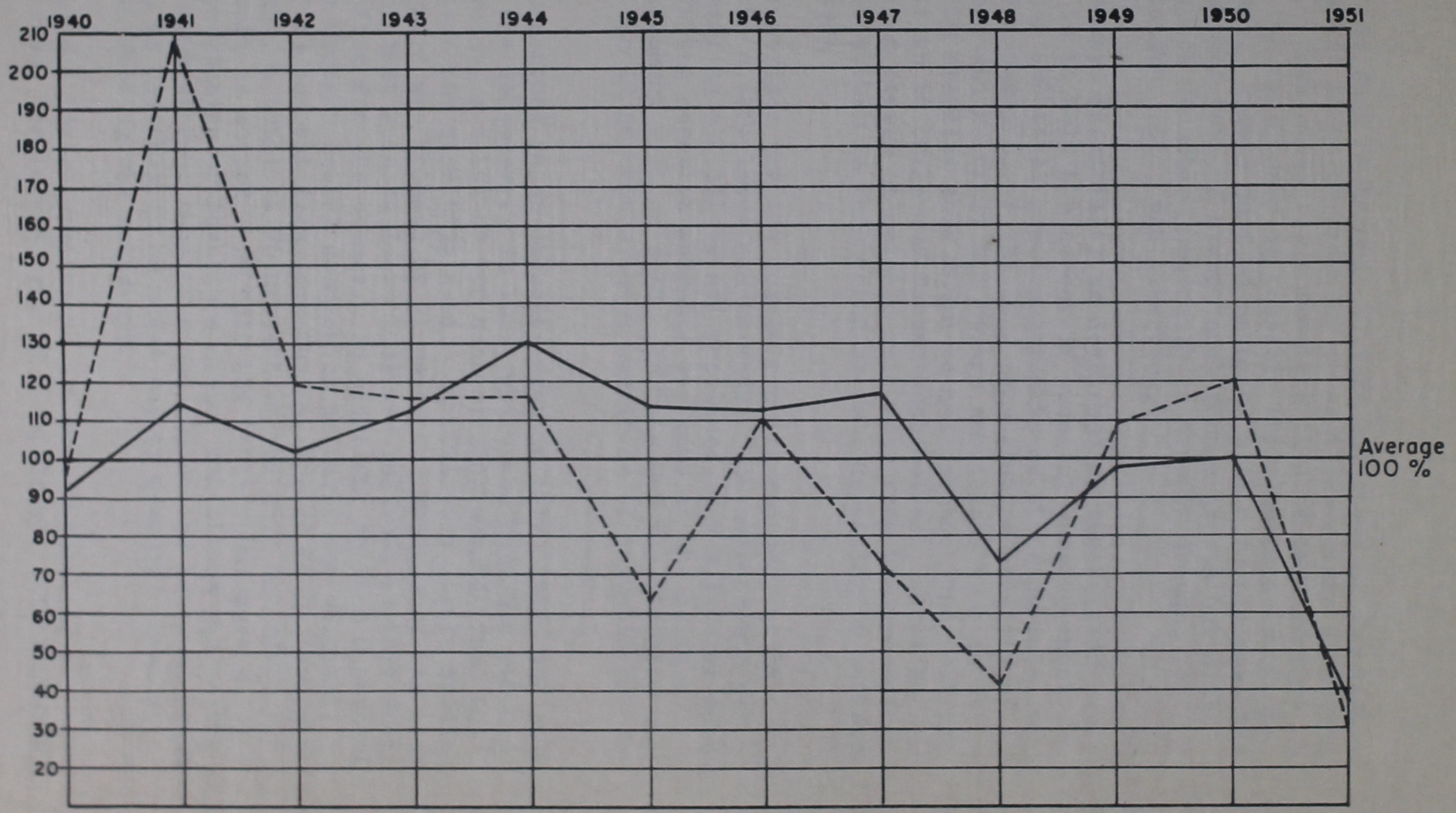
1916 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

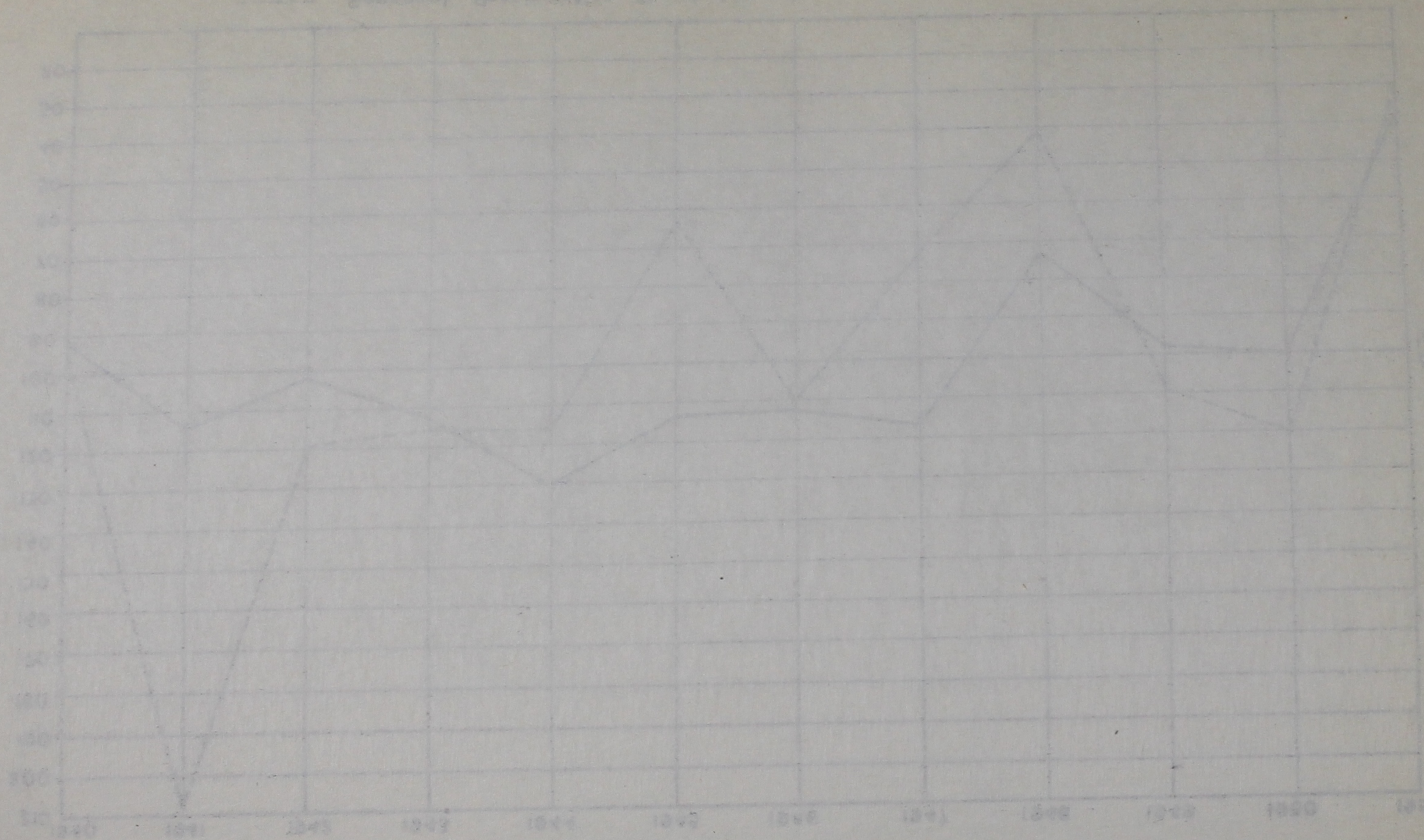
Grazing Year

Jornada Experimental Range

Forage Growth as Influenced by

Seasonal Precipitation (July 1 – Sept. 30)





It is just as good management to take advantage of the high producing years as it is to be prepared to meet the crisis presented by the low years. This calls for a flexible plan of herd management tailored to fit as closely as possible the fluctuations of unpredictable climate. Timely herd adjustments will not only make the most of the occasional year of exceptional forage growth but will also permit the quick reduction necessary in time of drought to protect the vegetation, soil, and livestock.

The key to herd flexibility as developed on the Jornada Experimental Range is to hold the number of breeding cows to about 55 to 60 percent of the total grazing capacity or stocking rate in average years. For example, if the long-time grazing capacity of a ranch is 1,000 head and rainfall and forage conditions were about average, 550 to 600 breeding cows would be maintained. The rest of the herd, in addition to bulls and replacement heifers, would be composed of yearling steers or heifers held over from the preceding calf crop for sale either in the spring or fall depending on markets and other variables.

If drought strikes and the forage crop is reduced, quick adjustments down to a safe level can be made. The adjustments are accomplished by selling all calves and yearlings, and a liberal cull of older cows. If the occasion warrants it, some of the heifers selected for replacement will be sold. In this way the stocking can be reduced more than 40 percent without sacrifice of valuable breeding animals.

For the occasional major droughts such as 1917, 1934, and 1951, drastic measures are necessary. In 1917, while the herd was reduced only about 30 percent, a total of 500 tons of supplemental feed was necessary to protect the remaining herd. In 1934 very little feeding was done but the herd was reduced by 71 percent. Because of the lack of feeding, the highest Jornada death loss was recorded in this year, nearly 5 percent from drought causes. In addition, another 8 percent was killed by the Drought Relief Commission as unfit for shipment, making a total of 13 percent loss directly attributed to the drought. In the 1951 drought, a total of 76 percent of the herd was moved out, all calves were sold as weaned, and only the better cows were maintained. Every opportunity of favorable market conditions was taken in order to sell cows without sacrifice and reduce the level of breeding stock as much as possible as an added safety measure. Even so, heavy supplemental feeding was necessary.

If rainfall and forage conditions are more favorable, or, as is sometimes the case, the forage crop is exceptional, all or nearly

all of the natural increase is held over. If these still do not match the current production of forage, outside cattle, mostly yearlings, are purchased and brought in to take up the slack. These are pastured through the fall and winter seasons, sold in the spring, or shipped out to other pastures for the summer.

The Annual Plan of Management

Some variation in details may be necessary in different localities, but the general principles of herd management used on the Jornada can apply over much of the southwestern range area. The procedure on the Jornada involves the following:

First, the herd is sized up well before the end of the growing season to determine what adjustments can most easily be made, if necessary.

Second, immediately after the growing season an inventory of the forage crop is made. This includes only perennial grasses and browse usable through the winter and spring months, making no provision for a winter weed crop which might not materialize. On the Jornada the inventory is made by sampling random plots on which the herbage is clipped. Allowance is made for the amount of herbage that must be left on the ground for soil protection and plant reserve; the remainder is considered as forage. This determination of forage yield is supplemented by extensive observation checked against experience in previous years. The final result is an estimate of available forage in terms of pounds per acre for each pasture or other range unit.

Third, the forage is then rationed by pastures according to the animal unit requirements of the operation, whether cow-calves, weaners, or steers. Based on "full feed," i.e., maintenance as well as production requirements, this ration fixes the proper rate of stocking for the ensuing season. The ration also provides a liberal reserve to carry the cattle through to a possibly late growing season the following year.

Fourth, marketing is planned and sales or purchases are made to shape the herd for the ensuing season, based on the foregoing determinations.

CLIMATE IN RELATION TO SHRUB INVASION AND CONTROL

by George E. Glendening

Climate and Broad Vegetation Types

Climate has been defined as "the sum total of the weather." It is made up of all the recognized factors of the atmosphere including light, heat, wind, and precipitation. Climate plays an important role in respect to the problem of noxious plant invasion and control in three major ways: (1) it has a direct effect in determining the kinds of plants which may invade and occupy an area, (2) it determines to a large extent the relative aggressiveness of these plants on a given site and (3) it may determine whether artificial control of that plant by chemical or mechanical means is practical.

Temperatures in the Southwest are generally favorable for plant growth. Consequently, amount and seasonal distribution of precipitation stands out as the most important factor in determining the broad vegetation types. For example, where rainfall is 5 to 6 inches per year, creosotebush and mesquite form a "desert shrub" type. With 18 to 20 inches of precipitation, as at Clovis, a buffalograss--blue grama "grassland" type occurs. In the higher mountain areas as at Cloudcroft, a precipitation of 24 or more inches supports a Douglas-fir type of "forest." These major vegetation types, "desert," "grassland," and "forest" represent the long time or final potential response to the prevailing climate.

As in all other regions, the climate in the Southwest is variable from year to year. This is especially true as regards precipitation which on the Jornada Experimental Range has varied from a low of 3.67 inches in 1951 to a high of 17.74 inches in 1941. Yet, since about 1880 when the rapid spread of noxious plants was first noted, the climate has been rather stable; that is, no definite upward or downward trend in degree of wetness or in temperature has been demonstrated. However, the microclimate or the atmospheric conditions which immediately surround individual plants on specific sites, has been greatly altered in many places.

Changes in Vegetation as Related to Changes in the Microclimate

The margin or tension-zone between the sand dunes and a grassland type, is a good place to discuss the effects of changes in microclimate upon shrub invasion.

In this area, despite the low average annual rainfall of only about 8.5 inches, the concentration of rainfall during the growing season (60%) together with the light sandy soils has resulted in well developed grassland. At the same time, it is readily apparent that

the interaction of another climatic factor, namely "wind," with the sandy soil and an invading plant, mesquite, results in dune formation. Some data on changes in plant populations and amount of ground cover, as determined from measurements made along a 1,500-foot belt transect in 1935 and repeated in 1950, are shown in the following table.

Changes in vegetation along the 1,500-ft transect in number of plants and in number of feet of the transect where they occur

Vegetation	1935		1950		Percent change of plants	Pct. change in feet occupied
	No. plants	No. ft. occupied	No. plants	No. ft. occupied		
Mesquite	16	98	36	171	-125.00	+74.5
Snakeweed	81	60	55	56	- 32.10	- 6.7
Black grama		696		533		-23.4
Dropseed		85		41		-51.8
Soapweed	9	7	14	13	+ 55.5	+85.7

These data show that black grama, dropseed, and snakeweed have declined during the past 15 years while soapweed and mesquite have increased on the transect.

Measurements show that individual sand dunes have moved eastward along the transect with four old dunes moving across and one new dune developing on the transect. Grazing use near the transect has been quite moderate. During the past 6 years it has varied from 8.3 to 33.4 percent, and has averaged only 24.5 percent of the total herbage produced.

Conclusions to be drawn from this study are (1) that during the past 15 years the microclimate at the soil level in the black grama type has been altered enough to allow the removal of the sandy soil from that site at an accelerated rate, (2) that the presence of mesquite, with its layering habit of growth, furnishes a mechanism for the deposition and accumulation of wind-borne soil particles in the form of dunes, and (3) that prompt elimination of mesquites in the black grama type and maintenance of maximum grass cover appears essential if further dune formation is to be prevented.

Campbell, who studied the successional processes in the sand dunes suggested that climate, specifically prolonged periods of drought which thinned out the herbaceous cover, were a factor in dune formation. Precipitation is less effective where velvet mesquites have encroached on former grassland sties according to data obtained on the Santa Rita Experimental Range in southern Arizona. This favors the further increase

in mesquite and greatly retards the establishment and growth of perennial grasses. On the sites in question the average annual rainfall of 13 inches is about the minimum that will support a stand of perennial grass; providing there is little runoff and most of the moisture remains on the site where it falls. With any marked reduction in grass cover, much of the high intensity summer precipitation runs off the site. In effect, an artificial summer drought is produced, much to the detriment of the grasses which require moisture during warm weather for germination and seedling establishment as well as for growth.

Moisture from the more gentle storms during winter penetrates to the deeper soil levels. This is of little value to the shallow-rooted grasses; but for the deep-rooted mesquites it allows root growth during winter and the renewal of top growth during the spring. In addition to their tap-root, mesquites possess extensive shallow lateral roots which, when the trees become dense, so completely utilize soil moisture that the supply for grasses is inadequate. Under such conditions, and in contrast to the perennial grasses, drought resistant desert species, including cholla and pricklypear cactus, if present, may increase rapidly. This relationship is strikingly illustrated in the following table which shows the changes that have occurred after mesquite invaded a former grass stand. The area receives an average of 12.9 inches of moisture and has been protected from cattle grazing since 1931.

Vegetation change following establishment of mesquite on a semiarid grassland site

	Mesquite (No.)	Cholla (No.)	Pricklypear (No.)	Perennial grass 1/ ($Cm.^2$)
1932	62	6	0	213.6
1949	137	314	47	5.1
Change	+ 75	+308	+47	-208.5

1/Mainly Rothrock and black grama.

Aggressiveness and Permanence in Relation to Climate

Each of our noxious plant species is adapted to best growth under a particular set of climatic conditions, which determines its final range or distribution, and largely defines the areas within which it may become a serious pest. All, however, possess varying degrees of tolerance in their specific requirements for growth; and occasionally are established well beyond their optimum climatic

range. Generally, plants growing on sites where they are not well adapted climatically do not become permanently established in large numbers. For example, pricklypear is not well adapted and is not usually considered a serious problem on the shortgrass ranges of Colorado. However, during the unusually dry 1930's, it increased rapidly and was the subject of considerable control effort. When normal moisture conditions returned, most of the pricklypear died off as a result of increased grass growth and the action of parasitic insects. Control of pricklypear by a similar climatic process cannot be expected on the semidesert grasslands of southern Arizona and New Mexico where the plant is well adapted to the dry climate.

Snakeweed populations tend to reflect trends in moisture to about the same extent as to the associated grasses in the grasslands of southern and eastern New Mexico. Because of this, competition by grasses for moisture can be important in controlling relative abundance of this noxious plant. The closely related and poisonous burroweed occupies a parallel role in the grasslands of southeastern Arizona. It, too, is a prolific seeder and capable of rapidly occupying bare soil; but does not become a serious problem except where grass cover has been reduced by drought or misuse.

Mesquite, which occurs on some 60 to 70 million acres in the Southwest, grows under an extremely wide range of moisture conditions, being found on sites receiving as little as 5 and more than 30 inches of rainfall. This plant is best adapted to high temperatures. Throughout the warmer parts of the region it is increasing rapidly. However, along its northern limit, as in Kansas and Oklahoma where its tops are killed by low temperatures, it spreads only slowly or not at all. Mesquite now ranges upward into the oak woodland in southern Arizona and New Mexico; but does not appear to be capable of rapid increases and likely will not create a problem.

Even when growing on former grassland sites mesquite does not reproduce with equal abundance annually, as indicated below:

Total number of seedlings emerging on 3 sites by years

	1948	1950	1951	1952
Number of seedlings	1,017	256	243	6

Some of this difference is related to seed supply, but even where seed is artificially planted, establishment of mesquite seedlings does not occur in equal amounts each year.

Climate as Related to Reproduction of Noxious Plants

Successful reproduction of long-lived trees is sporadic in this region and occurs only when years with climate favorable for seed production are followed by a year favorable to establishment of seedlings. Ponderosa pine seedlings were thus established throughout the pine belt of Arizona in 1914, 1919, 1929, and 1937.

Stands of Utah junipers at Drake, Arizona, and of alligator junipers at San Carlos, show definite age classes thus indicating similar past years or periods exceptionally favorable for establishment of juniper seedlings.

Seed production and seedling establishment of snakeweed and burroweed are also closely tied into climate. For example, in southern Arizona, burroweed produced an abundance of seed during the fall of 1951. This, together with the wet cool winter and early spring of 1952 set up conditions which were favorable for germination and emergence of seedlings. More than 300 seedlings per square yard germinated in some areas. Although the dry summer has eliminated a large percentage of these seedlings, a stand of new burroweeds is apparently established on those sites which were not fully occupied by perennial grasses.

Climate and Effectiveness of Herbicides

Climatic conditions, especially temperature and precipitation, affect the timing as well as the amount and kind of growth which plants make. Our tests indicate that the physiological status of a plant at the time it is sprayed is the most critical factor in determining its response to the new selective herbicides. From a practical standpoint, the success and failure of some large scale noxious plant control programs have been attributed to favorable or unfavorable climatic conditions.

Numerous tests under a variety of conditions show that foliage sprays of 2,4-D and 2,4,5-T are not effective on woody plants unless applied while plants are growing rather rapidly and at the proper stage of growth. This critical period of susceptibility varies for different plants and on different sites. For mesquite in southern Arizona our data appear to show that the best period is during spring when the trees have reached full leaf and pods are 1/4- to 1-inch in length. The actual date depends on local weather conditions, mainly temperature, and has varied from April 15 in 1949 to May 28 in 1952. During a given year attainment of the full leaf-early pod stage of development is delayed about 7 to 10 days for each 500-ft

increase in elevation. We also have limited data indicating that soil moisture influences the relationship between vegetative and reproductive growth in mesquite, and may be of importance in determining whether the mesquites will be susceptible to the 2,4,5-T.

On burroweed and snakeweed, rapid and active vegetative growth during spring is required for effective control with 2,4-D sprays. Since these plants grow during cool weather, the availability of spring moisture usually regulates growth and determines the advisability of attempting a spraying program. Repeated tests have shown us that 2,4-D is not effective on burroweed or snakeweed under drought conditions.

From laboratory and field studies we have evidence that weather conditions at time of treatment may strongly influence the effectiveness of foliage sprays. Cool, damp weather that reduced evaporation of the herbicide from the leaf surface and allows more of the toxic material to enter the plant is ideal. In contrast, when spraying is done during high temperatures part of the herbicide is immediately lost to the atmosphere by evaporation, and that which reaches the leaves dries rapidly. In this region, spraying ought to be done at the time when temperature is minimum and relative humidity is maximum. Ordinarily, these conditions can best be obtained during the first two or three hours of daylight.

Climatic Conditions and Mechanical Control

Climatic conditions often have an important bearing where mechanical control is being considered. For example, studies show that removal of the tops of burroweed and snakeweed will kill these plants if done while the roots are low in stored carbohydrates and the plants are under maximum stress for moisture. These conditions usually exist at the end of the spring dry period in May or June, at which time both plants can be effectively controlled by mowing or burning. The control of sandsage by mowing in the spring is based on the same relationship of top removal during the period of minimum carbohydrate reserves.

Mechanical uprooting of large trees such as mesquites and junipers by use of bulldozers or similar equipment can be, and commonly is, done without regard to climatic conditions. However, in cases where control is attempted by "chaining" or "cabling" more of the trees will be uprooted if the work is done while the soil is moist.

The effectiveness of hand grubbing, the cheapest and most practical method for controlling the early invasion of noxious shrubs, is not related to climate. It can be done at any time of year.

FENCING COSTS CAN BE GREATLY REDUCED BY USING PRESERVATIVE-TREATED POSTS

Lincoln A. Mueller

Estimates as to the number of fence posts used annually in the State of New Mexico varies from 500,000 to 1,000,000. Assuming that the actual number is somewhere between these limits, or approximately 750,000 posts, one can readily visualize the magnitude of the fencing job in the State, both from the standpoint of volume of wood required and cost to the ranchers and farmers.

There is little likelihood that the fence-post demands will diminish in the future as the trend has been toward more fencing as land-management practices are intensified. Another factor that adds to the problem is that the supply of good quality juniper, that is, juniper with a high proportion of heartwood, or the dark-colored wood found in the post, is rapidly declining. As a result less durable juniper along with other species of low durability are being used for fence posts. Light-colored wood found in the outer portion of juniper posts offers little or no resistance to decay attack. This is true for practically all species regardless of the durability of the heartwood and accounts for the need of using a high percentage of heartwood in woods having high natural decay resistance.

Estimates on the price of untreated posts throughout the State vary from 20 to 60 cents, depending on the quality and availability. Assuming that the average cost per post is 30 cents, and the setting cost around 20 cents, the total annual cost per post installed is 50 cents. This is a conservative estimate, yet when applied to the total number of posts used annually in the State it produces the rather alarming total of $375,000 as the amount ranchers and farmers are paying annually for fence posts, the bulk of which are replacements.

What can be done about this cost? The obvious answer is to use more durable posts so as to reduce the number of replacements. Any extension in the life of the posts will have a direct effect on reducing the annual cost, as shown in the following table. Assuming that the bulk of the posts presently in use in the State are of a moderately durable species the annual saving in using treated posts would be approximately 2 cents per post, or a total saving of $15,000. Naturally the greater the natural durability a species has the less advantage there is in treating. There would be little to be concerned about if there were an adequate supply of good quality juniper. However, as the situation now exists, it is questionable as to how long even moderately durable posts will be available and perhaps a comparison between nondurable posts and treated posts should be considered. As shown in the table, the saving in using treated posts would be 9 cents per post or a reduction of $67,500 on the total annual cost.

Cost of Fence Posts

Species	Initial cost	Years of service	Annual cost
Nondurable[1/] Pine, aspen, Emory oak, silverleaf oak	$0.50	4	$0.12
Moderately durable[1/] White oak, Arizona cypress, mesquite, New Mexico locust	0.60	12-15	0.05
Durable[1/] Juniper, Gambel oak	0.60 75 untreated	15-20	0.04
Treated[1/]	0.75	20-30	0.03
Steel[2/]	1.00 more nearly 65-70 in 100 part lots	20 30-yr on SRGR	0.05

1/Meagher, George. Service record of wood posts in the southwest. Res. Note 120, SW For. & Range Expt. Sta., Tucson, Ariz. Aug. 1951.

2/What do fence posts cost on an annual basis? Tech. Note No. 341, Lake States For. Expt. Sta., St. Paul, Minn. Oct. 1950.

The annual cost of steel posts is slightly above treated wood posts. This may be a surprise to those who are of the opinion that steel posts are indefinitely permanent. However, when all losses caused by repeated bending and corrosion are carefully weighed the 20-year figure shown is about normal.

There are a number of methods by which wood fence posts can be preservatively treated. Two of the most common that are considered effective and also within the reach of the average farmer or rancher are the hot-and-cold-bath and cold-soaking methods. There are certain precautions that apply to all methods of treatment.

For best results the posts should be carefully peeled and well seasoned. Bark interferes with the preservative getting into the wood. Green or unseasoned posts likewise do not absorb sufficient oil, hence will not give the expected service. Furthermore, green posts will continue to dry after treatment and will frequently check through the treated wood, thereby exposing untreated wood. A good practice is to open stack the peeled posts for 40 to 60 days prior to treatment.

Another precaution, particularly in woods of low natural durability, is to see that the posts have a continuous layer of sapwood. Sapwood takes preservatives readily whereas heartwood does not. It is for this reason that in species of low decay resistance split posts are not recommended.

Coal tar creosote and pentachlorophenol, or penta for short, have proven suitable for hot-and-cold-bath and cold-soaking treatments and are widely used in the treatment of fence posts.

Coal tar creosote is one of the oldest and best known and most commonly used wood preservative on the market. Penta has been in use since about 1933. During this period it has established itself as an effective preservative for a wide range of uses. It is sold in flake or dry form and in concentrated and ready-to-use solutions. The concentrated form is the most popular and convenient for small plants as it can be easily mixed on the site to meet the requirements of the treating job.

The hot-anc-cold-bath treatment consists of heating the wood in the preservative in an open tank for a prescribed length of time and then quickly submerging it in the cold preservative for a similar length of time. This can be accomplished by transferring the posts at the proper time from the hot solution to the cold solution or by draining the hot preservative and quickly filling it with cold. The same results can be accomplished, although more slowly, by shutting off the heat and allowing the posts and preservative to cool together.

The time and temperature requirements are somewhat variable and usually must be adjusted according to treating properties of the wood. It is essential that all or a high percentage of the sapwood in the case of heavy-sapwood species is penetrated if long service is to be expected. Usually a temperature of 212 to 220 degrees F. is sufficient for the hot bath. The cold bath should be approximately 100 degrees cooler. Two to four hours in each solution is usually a good starting point as to time.

The principle involved in the hot-and-cold bath is one of expansion and contraction. The air in the wood is expanded during the heating and contracted during cooling. This change creates a partial vacuum which forces the preservative into the wood cells.

In addition to its effectiveness the hot-and-cold bath process is popular because of the low equipment costs involved. About all that is required is a 55-gallon tank or two and a thermometer registering to 235 degrees F. Commercial plants usually install a hoist and other labor-saving devices to speed up the operation.

The cold-soaking method is a relatively new method in the field of treating fence posts that has become popular in recent years. Its advantage lies in the simplicity and low cost. About all that is

required is a 55-gallon tank and the preservative. The method consists of merely soaking the posts in the preservative until all the sapwood is penetrated. The actual soaking periods must be adjusted to fit the need of the species. Easily treated woods for which the method is especially well suited can usually be treated in 24 to 48 hours. Since there is no heating involved there is little fire hazard and, aside from occasionally checking the oil levels, the method requires very little attention. Since the preservative is not heated it is necessary to use the less viscous-type preservatives. Pentachlorophenol, when used in solutions of fuel or diesel oils or lightweight crank-case oil, is ideally suited for the process. The method is particularly well adapted to farm and range conditions where it is frequently necessary to carry on several jobs at a time and with a minimum of supervision.

Either method can be applied as a butt treatment or as full length. In the former only the portion of the post that is set in the ground is treated while in the latter the entire length is treated. Throughout arid regions such as the Southwest butt treatment is usually adequate.

THE EFFECT OF RAINFALL ON PRODUCTION BY RANGE CATTLE

J. H. Knox

The growth of range plants on the College Ranch and much of the Southwest occurs in two seasons. Summer rains coming in July, August, and September produce the principle volume growth on the major grasses which, in our case, are black grama, dropseed, and tobosa. The extent and nature of this growth not only determine the gains made by cattle during summer and early fall, but also determine the amount of winter feed produced. In this respect the importance of these summer rains can scarcely be overemphasized. On grassland ranges they determine almost entirely the amount of winter feed and the carrying capacity of the range.

The other season of growth is in the spring. The amount of this growth depends mostly on rain and snow in late fall, winter, and spring, although it is influenced by spring temperatures and winds. The extent and kind of growth varies greatly. Following good fall rains, annual weeds may germinate which live through the winter and reach a size that may be grazed in the early warm days of February. Rain or snow in mid-winter and early spring may cause a later growth of weeds coming in March and April, while rains in mid-spring or later may cause these annuals to persist rather than dry up as is the usual case and can result in some growth of early grasses such as threeawns and dropseed. Yucca blooms which are often a factor seem to result from either winter or spring rains. It is possible for some green feed to be available from late February to July when summer rains may start. This almost never occurs, however, because the average rainfall, for the 18 years reviewed in the nine months from October through June was 3.1 inches. The largest amount was 5.3 inches and the smallest 0.92 inch. Green feed on the grassland ranges as the result of spring growth is not abundant for any considerable period. The difference between a good spring and an average spring is the difference between a small amount and a little, and the difference between a medium and poor spring is the difference between a little and a very little or none at all.

Such new growth seldom greatly affects the total volume of feed produced and the carrying capacity of the range but it improves the quality of feed consumed by the cattle. The feed is more palatable so more is consumed. The presence of even small amounts of green feed in the form of weeds or young grass increases remarkably the vitamin intake and reduces materially any mineral and protein deficiencies. The result is stronger calves at birth, cows that give more milk, and yearlings that shed quicker and grow faster.

The following data are obtained from the summary of records on the College Ranch from October 1933 to October 1951. These records cover the two severe drought years, 1934 and 1951, and two years of unusually heavy rainfall, 1941 and 1942. The average rainfall was

8.4 inches, with 3.1 or less than 40 percent falling in the nine months from October to June and 60 percent or 5.3 inches in the three remaining summer months. In this discussion the seasons are ranked as good, medium, or poor, depending on how the rainfall compares with these averages. Since winter and spring rain is expressed by spring growth, the precipitation for this entire period is used as a measure of spring conditions. In order to coincide with dates for weaning calves and weighing yearlings, years in this discussion are from October to October.

The following table shows the average calf weights and yearling gains for years with varying combinations of seasonal conditions.

		Calf weights (Lbs.)	Yearling gains (Lbs.)
Good summers	+ good springs	444	359
	+ medium springs	434	363
	+ poor springs	416	332
Medium summers	+ good springs	444	353
	+ medium springs	427	361
	+ poor springs	364	200
Poor summers	+ good springs	383	218
	+ medium springs	383	230
	+ poor springs	330	162

The most obvious thing is that poor summers, as would be expected, result in low production. A more surprising thing is found in the comparison of good and medium summers. Here we find that summers with heavy rainfall produce little heavier calves and yearlings than those that have a medium amount of moisture unless the medium summer is preceded by a bad spring. This can be explained by the fact that medium summers produce ample forage. The advantage of the unusually good summer is an increased supply of winter feed and an improved vigor of the grass stand rather than increased weight of calves and yearlings. The situation is different in the spring when green feed is seldom abundant for a long period. Here we find that good spring feed conditions result in somewhat heavier calves than those weaned after a medium spring. The difference is not as large, however, as that between medium and poor springs. In the case of yearling steers medium springs resulted in as much as good springs. This indicates that a small amount of green feed meets the requirements for growth of yearlings better than those of suckling cows.

The second table shows the effect of seasonal conditions when combined with various moisture conditions in the following or preceding season.

Season and Moisture condition	Average annual rainfall (In.)	Average calf weights (Lbs.)	Average yearling gain (Lbs.)
Good summers	7.65	435	351
Medium summers	5.06	412	305
Poor summers	2.08	365	204
Good springs	4.58	426	310
Medium springs	3.53	415	318
Poor springs	1.97	370	231

Here again it may be seen that the differences between good and medium seasons are small but the differences between medium and poor seasons are large. Also, medium springs seem to result in as good steer gains by fall as springs with more rainfall.

By referring to the first table it will be seen that the really bad years when poor springs are followed by poor summers result in a greater reduction in yearling gains than in calf weights. Yearling gains are about one-half of normal while the calves weigh about 75 percent of the weights in better years. This may be due to the withdrawal of reserve flesh from the cow in order to nourish the calf. But there is another angle to the situation which should be considered. Dry summers usually result in fewer calves being born the following spring.

The last table gives some information on that subject.

Moisture Condition	Average rainfall	Average percent cows which calved°
Following good years	12.09"	95.1
Following medium years	9.09	94.0
Following poor years	6.36	89.1

°Does not include 1936 when percentage of calves born was low because of trouble with bulls the preceding year.

The difference between the number of calves born after good or medium rainfall years may not be significant. The reduced percentage following poor years is significant and largely offsets the lower production from steers in the drought years.

Conclusions

1. As would be expected, lowest cattle production came in years when bad summers followed bad springs.

2. Above average summer rainfall only slightly increased the weight of calves and gains made by yearling steers.

3. Below average summer rainfall decreased production much more than above average rainfall increased it.

4. Weaning weight of calves increases as spring conditions improve. However, better than average spring conditions did not seem to increase the weight of yearling steers in the fall.

5. Severe drought decreased the gains of yearlings proportionately more than the weight of calves but this was offset by more cows which failed to calve in springs following dry years.

MANAGEMENT AND PRODUCTION ON THE COLLEGE RANCH DURING DROUGHT

K. A. Valentine and J. J. Norris

In keeping with the general subject of today's program, we are going to discuss in a general way the management and overall production on the college ranch through recent years, some of which have been characterized by severe drought conditions. Actually we must include a period of years in our discussion, rather than only the drought years, because the management possibilities in drought years depend in a large part upon the management that has been in operation before drought begins.

There is no question but that drought is one of the most difficult problems with which the southwestern rancher has to contend. He is adversely affected by drought in four important ways:

1. Range is damaged to varying degrees, sometimes requiring several years to restore to original productivity.

2. Breeding stock, commonly representing years of careful management and expense, must be sacrificed.

3. Current production and income is decreased.

4. Feeding or shipping to feed is resorted to and while this may reduce some damage and loss it is done at considerable expense.

It is hardly reasonable to expect that any method or practice can be devised that will entirely offset the effect of droughts, especially more severe and extreme droughts. It is reasonable, however, to expect that some practical means of materially reducing the ill effects of drought can be developed and it is the purpose of this discussion to present the findings here on the ranch as a contribution toward that end.

Drought has been variously defined and yet no definition seems to be entirely adequate. It has perhaps most commonly been defined in terms of rainfall deficiency for certain periods or sequence of days. This is not a wholly satisfactory basis for defining or evaluating drought. Rainfall before the onset of the dry period, and temperature, wind movement and distribution of rainfall within the dry period are all variables which can increase or decrease the severity of drought as expressed by deficiency of rainfall alone. Despite the shortcomings of any definition of drought we shall be compelled in our discussion to adopt some measure of drought, arbitrary and imperfect though it may be. The one we shall use is a simple one which considers that 85 percent of average is significantly below average and therefore to be regarded as separating average from drought years.

Since all drought is not equally severe we have, for the purpose of classifying droughts, set off 20 percent ranges below the 85 percent point, i.e., 85 to 65 percent, 65 to 45 percent, and 45 to 25 percent as delineating increasing degrees of drought which we have designated as moderate drought, severe drought, and extreme drought, respectively. These divisions are quite arbitrary but some such division is necessary if we are to analyze our rainfall records. We have called years between 85 percent of average and 115 percent of average normal or average years and have divided the above-average percentages into three 20 percent ranges and called them good, very good, and excellent. Actually there are some years that fall outside the wide total range thus delineated, that is, below 25 percent of normal and above 175 percent of normal. But since we have used up our superlatives of description we shall be content to call them phenomenally good or bad years.

Recent experience leaves no doubt in anyone's mind that drought is a very real hazard to the southwestern rancher, but this tells us nothing of its frequency of occurrence--its continuing menace. How much drought do we have on southwestern rangeland? By examining long-time weather records we get a pretty good answer to this question.

Let us consider briefly the long time record for a representative station here in the Southwest. This record is for State College, one of the drier locations in the state but one that is believed to be representative of the variations that are experienced. The rainfall included in this record is growing season rainfall, that is rainfall that comes at a time of year when temperature is high enough to promote the growth of the chief forage plants. At State College and throughout the southern part of the state this is rainfall from about June 20 to about October 10. Before this time rainfall is too deficient and after this time temperature is too low, generally speaking, to promote much growth of the main forage species.

Now referring to this record in Chart 1, we see that the forage producing rainfall is highly variable in amount and in distribution over sequences of years. Variation in amount runs from 24 percent of average to 251 percent of average. Some sequences of years are good, some are droughty, and in others good and bad years follow each other seemingly at random. Some profess to see cycles in such rainfall patterns and this may be true for some records but nothing in the way of a cycle seems apparent in this record.

Classifying the years we find only 22 in number or 37 percent that can be regarded as average according to our definition above. Six years or 10 percent were moderate drought, 12 or 20 percent were severe drought, and 1 year or 1.7 percent extreme drought. One year

Kind of Year	Number of Years	Percent of Years	Percent of Average
	1	1.7	235
	0	0	215
	0	0	195
	1	1.7	175
Excellent	4	6.3	155
Very Good	4	6.3	135
Good	8	13.4	115
Average	22	37.1	100
			85
Moderate Drought	6	10.0	65
Severe Drought	12	20.0	45
Extreme Drought	1	1.7	25
	1	1.7	0
Totals	60	100.0	

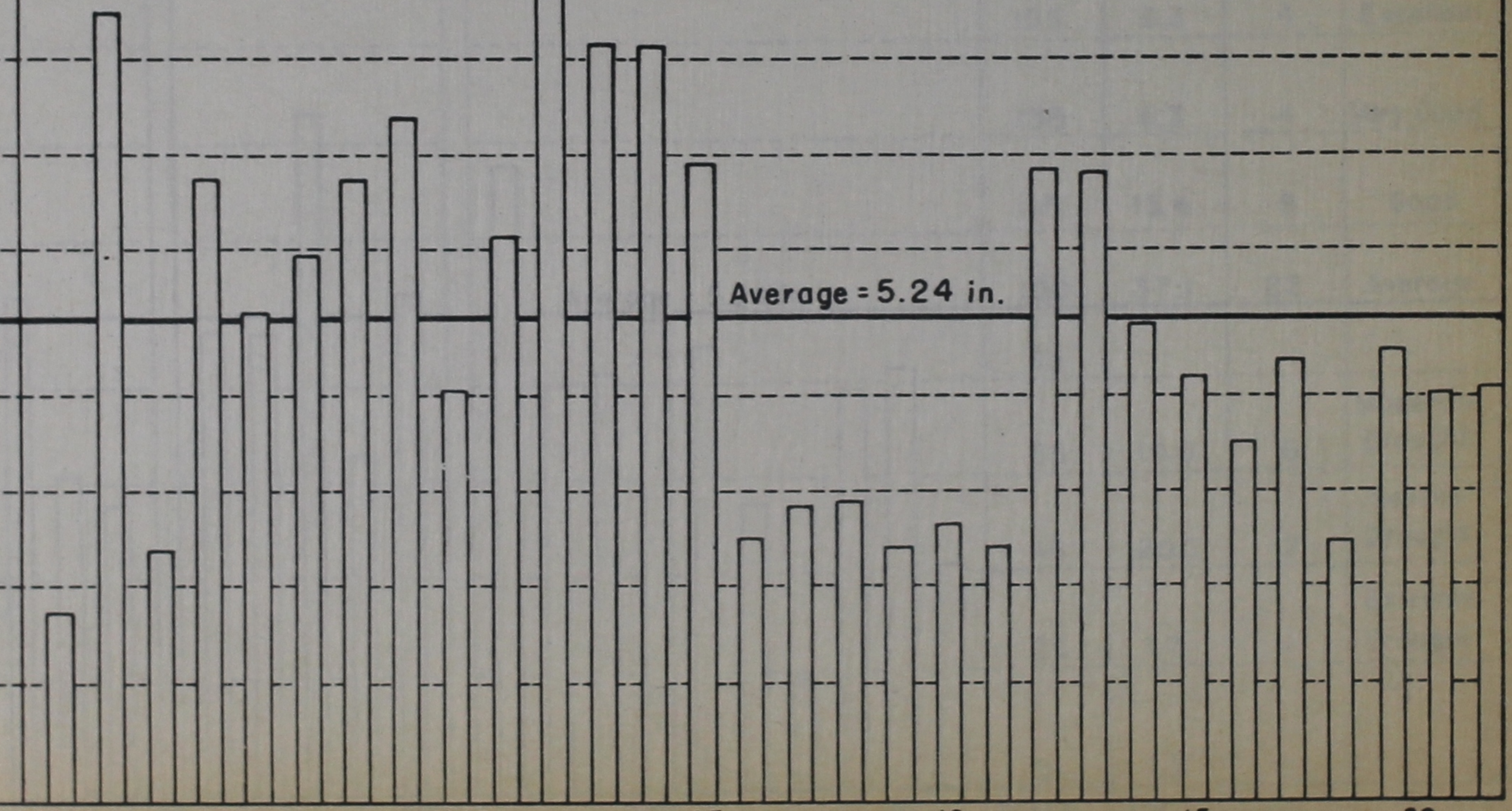
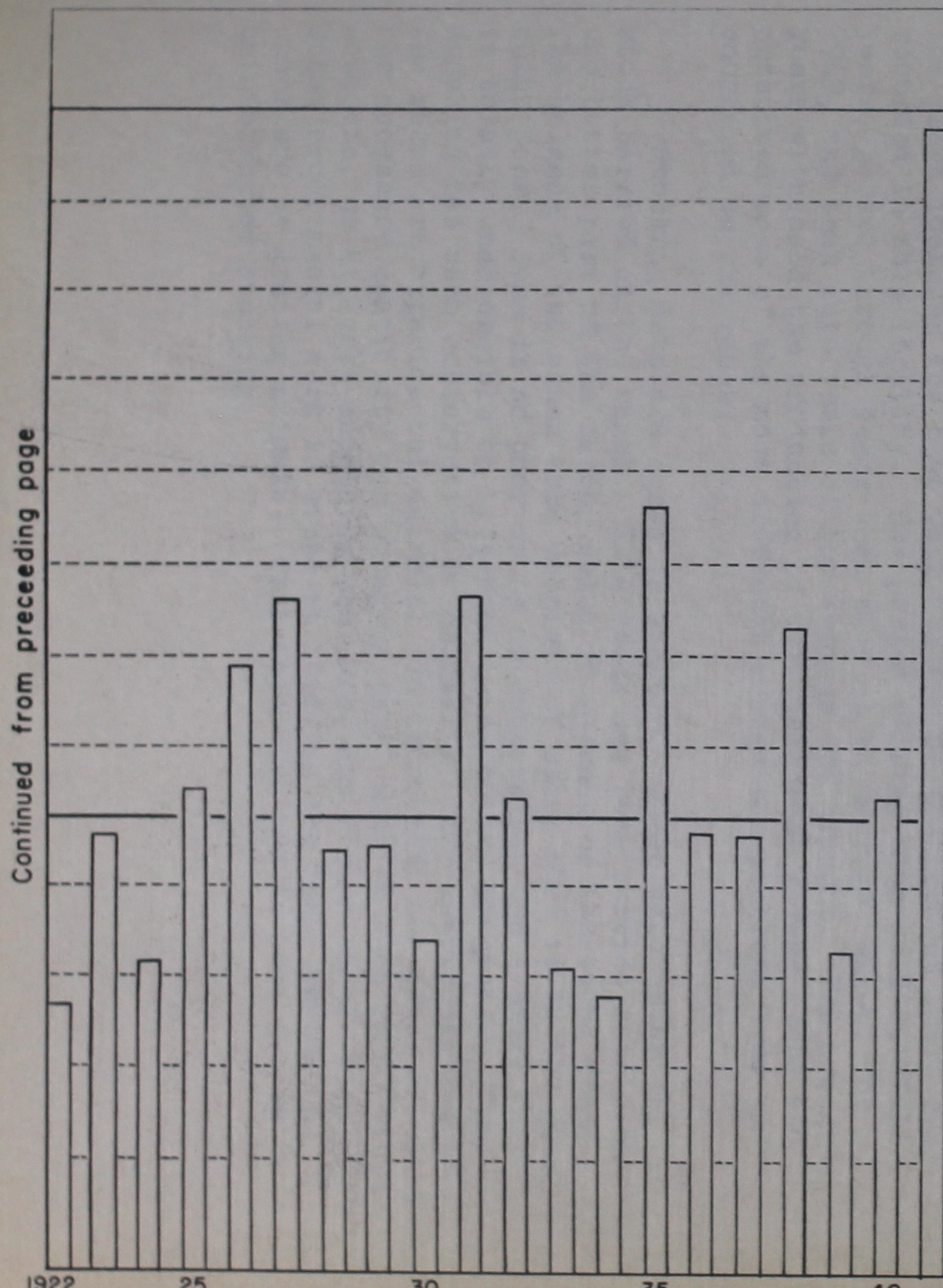


CHART I. Seasonal Rainfall in Percent of Average- 1892 to 1951, State College. (60 Yr. Record)



Percent of Average	Percent of Years	Number of Years	Kind of Year
235	1.7	1	
215	0	0	
195	0	0	
175	1.7	1	
155	6.3	4	Excellent
135	6.3	4	Very Good
115	13.4	8	Good
100	37.1	22	Average
85			
65	10.0	6	Moderate Drought
45	20.0	12	Severe Drought
25	1.7	1	Extreme Drought
0	1.7	1	
Totals	100.0	60	

Chart I. (Con't.) Seasonal Rainfall in Percent of Average - 1892 to 1951, State College. (60 Year Record)

with less than 25 percent of average goes off our adjective scale. An even one-third of the years then have been characterized by moderate drought or worse. Considering the period, decade by decade, there were two which had two drought years, three which had three drought years each, and one in which six years of drought occurred. This record is indicative of a drought problem of no mean degree that confronts the rancher on southwestern ranges. There is a brighter side of the picture of course; above average years do occur. Eight (13.4 percent) were good, 4 (6.3 percent) were very good, and 4 wers excellent. Two (3.4 percent) of those phenomenally good years occurred. These years do not present the problems in which we are at present interested, however.

Let us turn now to the ranch records for our further discussion. These records are of three kinds: growing season rainfall, stocking, and beef production for the period 1940-1951, all presented in terms of percent of average.

The rainfall data shown in chart 2 are taken from the five gages on the college ranch that represent the stocked pastures. The chart shows the year by year averages of these gages graphed as a percentage of the last 26 years'average as computed for the Jornada Experimental Range headquarters. The period covered by the graph includes the best year and two of the poorest years ever recorded in this locality. The period started with good rainfall years, passed through years that were about average, except for 1943, and then into years of low average and drought. The drought years witnessed the production of very deficient forage crops and presented some of the most difficult management problems ever encountered on the ranch.

Stocking data are shown in chart 3. These data cover all stock carried on the ranch. This stock has been carried mainly on the better part of the ranch, about 38 percent of the total area. The balance of the ranch area consists of range that is in the main quite poor. Some is so poor as to be submarginal and a small part is totally unaccessible to livestock owing to its roughness. The stocking has been conservative of necessity. All cattle carried on the ranch are experimental animals. In order that the experiments have the necessary continuity the stocking level must be such as to allow adequate, or at least something near adequate forage at all times. Other experimental work is aimed at studying the range vegetation under use by grazing animals. This objective too is best met by uninterrupted stocking.

The stocking level adopted has allowed a more uniform stocking from year to year than the seasonal rainfall would support if its ups and downs were followed closely. No severe reductions in stocking have been forced by critical lack of forage. The greatest reduction came in 1949 because no steers were held over from 1948 owing to the drought of that year. In no other year has stocking been reduced as much as 10 percent below average. This has been possible only because stocking at the outset was conservative. This is not to say that there was an abundance of feed all through the period. Feed was deficient in quantity and quality during the drought years but the stock was carried on the range in but slightly reduced numbers and without critical grazing damage to the range.

Production data are shown in chart 4 and include production from cows, calves, and steers. Production showed a greater drop off during the recent dry years than has stocking. It has not, however, fallen as much below normal as rainfall. This may be attributed to maintenance of nearly normal stocking which has partially offset the reduced unit rates of production in the dry years.

Now let us consider the results attained, judging them in the light of the main hazards of drought listed at the outset. We have seen a fairly representative part of the range coming across the ranch to this point. It had sufficient reserve of emergency forage to make up for the deficient growth of the drought years. It did this without sustaining excessive damaging use and remains in fairly good productive condition. Drought has damaged it to some degree but the residual stand and vigor of the vegetation and condition of the soil is adequate to bring about rapid recuperation to its former productive state, under normal conditions.

Third, production during and following the drought years has remained reasonably high. Although it did drop in 1951 to 68.7 percent of average (the lowest in the record). This would seem to be quite acceptable in a year when grazing season rainfall was but 28.4 percent of average.

Lastly, this has been done using only the forage resources on the ranch. No emergency feeding has been done nor have any cattle been temporarily removed from the ranch and later returned to it. To the practical operator this would represent the avoidance of reducing current income or cash reserve, or more commonly of incurring indebtedness through emergency feeding.

Chart 2 - SEASONAL RAINFALL IN % OF AVERAGE, COLLEGE RANCH, 1940-51

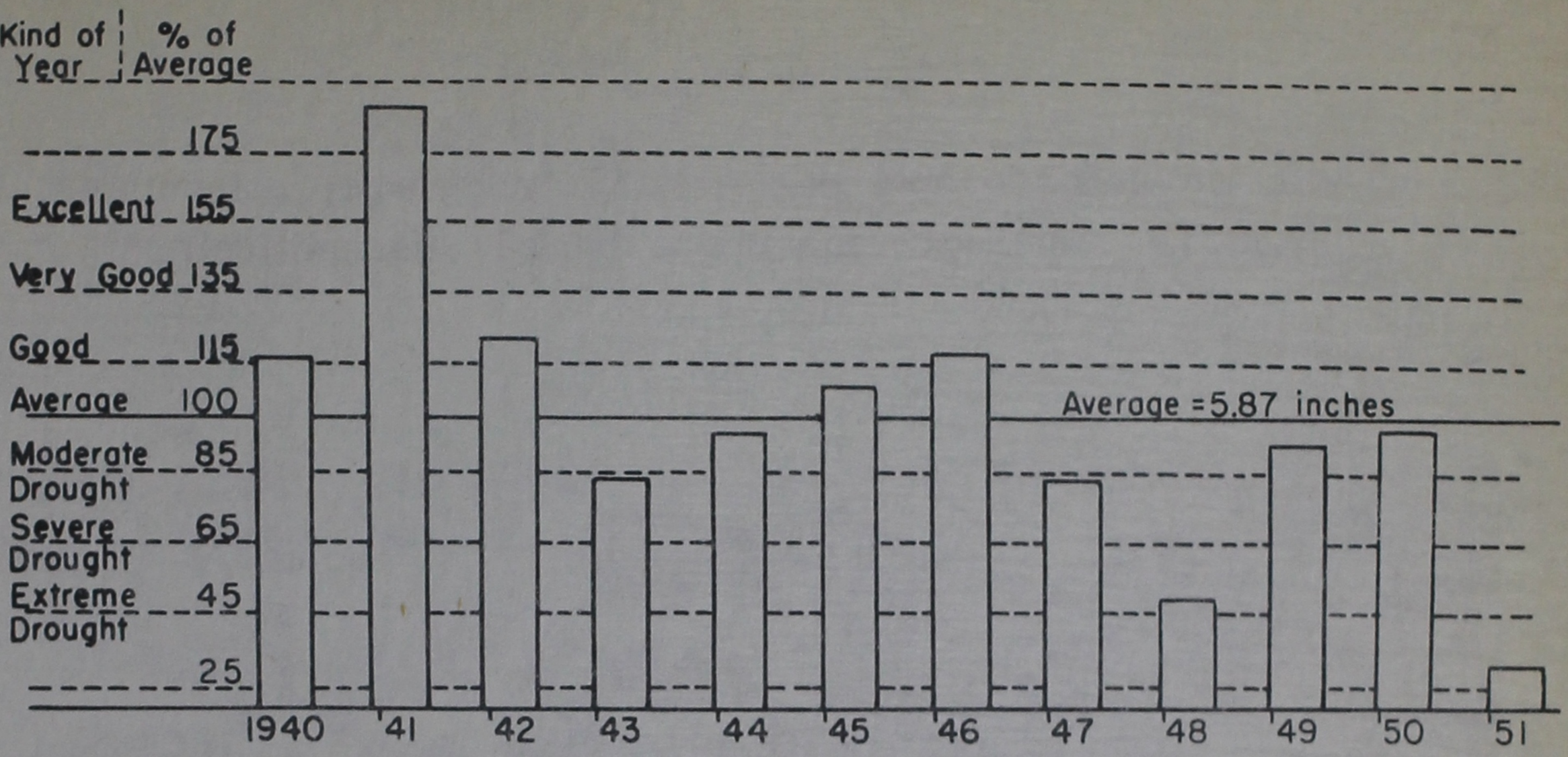


Chart 3- STOCKING IN % OF AVERAGE, COLLEGE RANCH, 1940-51

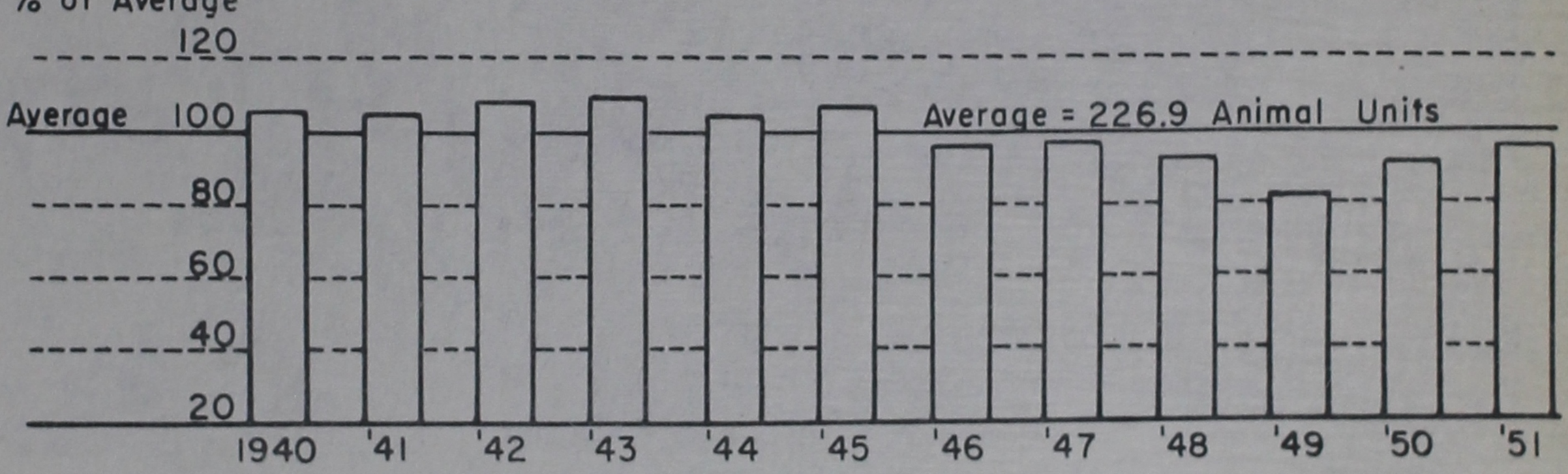
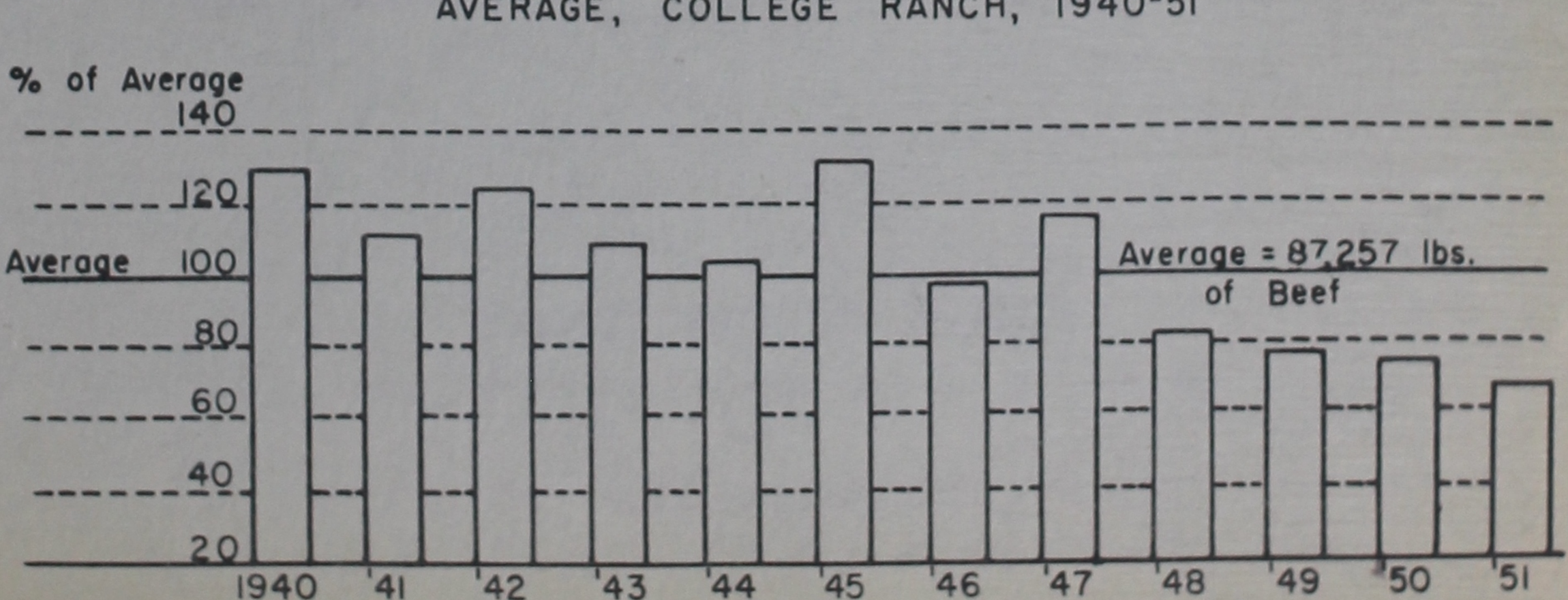



Chart 4- PRODUCTION (COWS, CALVES, & STEERS SOLD) IN % OF AVERAGE, COLLEGE RANCH, 1940-51